Atomic Energy of Canada Limited

A REPORT ON THE EFFECTS OF THE CHEMICAL EXPLOSION OF DECEMBER 13, 1950 AT CHALK RIVER NUCLEAR RESEARCH LABORATORIES

Prepared from the Official Records of
Atomic Energy of Canada Limited

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J.N. FAIRLIE and A.J.W. HITCHMAN

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SYNOPSIS

The chemical explosion at Chalk River on December 13, 1950 resulted in one death and injury to several other employees. Although radioactivity was present it in no way contributed to the cause of the accident, nor were there any radiation injuries.

The injuries and treatment are described. A record of radioactive contamination of the injured is included. The lessons learned from the accident are pointed out.

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INTRODUCTION

At 1:20 p.m. on December 13, 1950, a chemical explosion occurred at the Atomic Energy of Canada Limited, Chalk River, Ontario, in a pilot plant evaporator that was being used to concentrate radioactive fission products from a nitric acid - ammonium nitrate solution. The explosion resulted from the build-up of too large a concentration of ammonium nitrate in the hot evaporator concentrate.

The explosion destroyed the stainless steel evaporator tank and nearby concrete and wooden structures. The ensuing flash and shock wave dispersed metallic, wooden, and cement debris and dust contaminated with the radioactive contents of the evaporator into the surrounding area.

Although the presence of dispersed radioactivity necessitated extra work and care in cleaning up after the accident, and in the treatment of the injured, it in no way contributed to the cause of the explosion, nor did any of the men suffer any radiation injury.

INJURIES TO PERSONNEL

Four male employees were in the evaporator building at the time of the explosion:

Patient 1 This man was standing closest to the evaporator and suffered a flash burn of the hair and multiple lacerations of the scalp and extremities.

Patient 2 This man was lagging pipe about 20 feet from the evaporator. He suffered multiple small lacerations, especially on the face and upper extremities.

Patient 3 This man was the most severely injured of the survivors. He suffered many small penetrating wounds about the face, arms, shoulders and legs. The most extensive lacerations were on the right forearm and on the right side of the nose. Both ear drums were perforated by the shock wave.

Patient 4 This man was standing about 12 feet from the evaporator, and was killed by flying shrapnel.

The blast affected the ear drums of all the survivors. In general there was radioactive contamination on all the debris which settled on or

penetrated the skin barrier, and in the dust cloud which was inhaled by the injured until they were evacuated.

Three employees, patients 5, 6, and 7, outside the building suffered minor injury from flying debris. Table I summarizes the physical injuries of the men involved.

TREATMENT OF INJURED

The injured men were taken to the Plant Hospital where they were decontaminated and treated for shock. The surface decontamination of the patients' bodies involved removal of clothing, some hair, and extensive washing of the contaminated skin. Any easily accessible foreign bodies were removed from lacerations.

After the initial treatment and decontamination at the plant the patients were transferred by ambulance to the Village Hospital in Deep River, where further debridement of wounds was done under anaesthetic in the hospital operating room, with the assistance of a radiation surveyor from the plant.

Patient 1 was discharged from the hospital on December 21, 1950. He resigned from Atomic Energy of Canada Limited on discharge to seek employment elsewhere.

Patient 2 was treated at the hospital for about one week. He resumed work on January 8, 1951, and continued to work at AECL until March 24, 1953, when he resigned.

Patient 3 was discharged from hospital on December 23, 1950. He returned to work on January 16, 1951, in a clerical position. He resigned from AECL on February 27, 1953.

The body of 4 was decontaminated at the Plant Hospital and turned over to an undertaker for burial.

RADIATION ASPECTS OF THE EXPLOSION

The dispersal of radioactive matter by the explosion resulted in contamination of the skin and wounds of workers in the building. A record of this surface contamination is tabulated in Table II.

The possibility of internal contamination by inhalation of the dust

cloud, and absorption through the skin barrier and through wounds was also considered. Although fission product analysis of excreta was not a standard procedure at that time, the amounts of plutonium excreted appeared to represent internal contamination below the levels then considered permissible. (Table of Results) Table III.

LESSONS LEARNED FROM ACCIDENT

The accident faced the medical staff at Chalk River with the problem of treating wounded people contaminated with radioactive substances, and many useful lessons were learned from that experience. As a result a new personnel decontamination centre was designed and built. It is described in an article entitled "A Unique Decontamination Centre" by Dr. E.M. Renton, M.D., which was published in "Occupational Health Review" Vol. 6, No. 2, 21-24, November 1954. Reprints of this article are available from AECL as publication AECL-159.

Briefly, the lessons learned from the 1950 explosion were:

1. The need for a public address system which can be mounted on a fire-truck or similar emergency vehicle by which all non-essential personnel can be directed away from the scene of the incident.

2. No one should approach the scene of an accident without wearing a respirator, or until a radioactive survey has established that the area is not dangerous.

3. The Plant Hospital should be constructed so that there is one main entrance and one main exit. It should provide a large waiting room or pre-treatment room in which the injured can be undressed.

   It should provide a centrally drained floor and hose equipment so that the skin can be washed by hose and not with a multitude of dressings or bandages. Electric shears should be provided for removing the hair where necessary.

4. The hospital should be designed so that a change station can be put into operation quickly to prevent the contamination of the hospital proper by personnel entering and leaving.

5. It must be possible to monitor immediately all casualties admitted to the hospital.

6. In treating radioactive casualties one cannot transfer equipment from one patient to another. Therefore it is advantageous to have emergency sterile dressings and the necessary sterile surgical instruments wrapped and maintained in sets, in small packets, available for use separately on each casualty. It is important that these supplies be kept in a room or locker that is not accessible to anyone but authorized personnel, to prevent their being contaminated early in the procedure from the hands of the attendants.

7. Consideration must be given to the availability of a morgue for the retention of contaminated fatal casualties.

8. The sooner the injured arrive at the hospital and the less their subsequent movement until their condition is more accurately known, the better.

TABLE I

EMPLOYEES INVOLVED IN ACCIDENT, DECEMBER 13, 1950

Patient 1	Flash burn of face Lacerations scalp and extremities	Deep River Hospital 8 days	Did not return to AECL. Resigned Feb./51	Last seen 6.2.51 Perforation both tympanic membranes, Painful right elbow	No subsequent record
Patient 2	Multiple lacerations face, upper extremities. Right ear small perforation, left ear large perforation	Deep River Hospital 7 days	Resumed work 8.1.51. Resigned 24.3.53	Last seen May/52 Some hearing defect	No subsequent record
Patient 3	Lacerations face, arms, shoulders, legs. Perforation of both tympanic membranes	Deep River Hospital 10 days	Resumed work 16.1.51 in clerical position. Resigned personal reasons Feb./53	Last seen 27.2.53 All scars satisfactory Ear drums healed Hearing satisfactory	No subsequent record
Patient 4	Death from shrapnel injuries				
Patient 5	Bruise on lateral aspect of left Fibula	Treated in Plant Hospital	Not off duty	No further sickness referrable to this accident.	
Patient 6	Knocked out by flying debris	Deep River Hospital 3 days observation	Resumed work 18.12.50	No further sickness referrable to this accident. Still employed 1962.	
Patient 7	Struck on posterior aspect of left leg. No injury		Not off duty	Incident record is considerable but no accident or sickness referrable to accident of 13.12.50. Still employed 1962.	

TABLE II

SURFACE CONTAMINATION OF SKIN
(cpm ($\beta\gamma$) on Eck-Kreb Geiger held close to skin*)

Wound	Start Decontamination Dec. 13	Finish Decontamination - 14	Dec. 20	Dec. 28	Jan. 10	Jan. 31
Patient 1						
Head, right side	300	100	120	0		
back	200	-	120	0		
Leg, right	100	-				
left	200	20				
Elbow, right	100	20				
Ribs, right	100	20				
Patient 2						
Knee, left	50	0				
Back, upper	100	30				
Hand, right	100	0				
Ribs, left	100	20				
Forehead, left	400	150	150	0		
Cheek, left	500	100				
Arm, left upper	150	0				
Head, behind left ear	400	100	150	0		
Patient 3						
Neck, under chin	4500	1500	400	40	10	0
under left jaw	4000	1300	300			
under right jaw	-	-	200			
near right shoulder	-	-	500			
Face, across mouth	4500	1400	300			
right, near mouth	4000	800	-			
right cheek	3000	-	1000	60	30	0
Temple, right	3000	800				
Nose, right side	4500	-	800	120	120	60
Ear, right lobe	-	-	300			
Shoulder, left	600	400	150			
right	-	-	150			
Thigh, right	1000	300	300	50	20	20
Elbow, right	5500	-	1000	60	20	20
Hand, right	-	-	400	35		
Knee, right	-	-	100			
Abdomen	-	-	-	50		

* Efficiency under experimentally similar conditions for β emission with E max. in the range 0.5 - 2 MeV, 2-3%.

TABLE III

URINE EXCRETION DATA FOLLOWING THE EXPLOSION AT CHALK RIVER OF 13 DECEMBER, 1950

Date Sample Excreted	Approximate Elapsed days	24 hour excretions as Pu*
Patient 1		α dpm
December 14-15/50	1.5	2.8
December 16-17/50	3.5	1.0
December 19-20/50	6.5	<0.3††
January 23/51	41.0	<0.3††
Patient 2		
December 14-15/50	1.5	11.2
December 16-17/50	3.5	2.2
December 19-20/50	6.5	1.8
December 23-24/50	10.0	1.1
December 26-27/50	13.0	1.6
January 14/51	32.0	1.0
March 27/51	103.0	<0.3††
June 18/51	187.0	0.4††
January 21/52	404.0	<0.3††
May 29/52	533.0	<0.3††
Patient 3		
December 14-15/50	1.5	9.8
December 16-17/50	3.5	5.6
December 19-20/50	6.5	2.0
December 21-22/50	8.5	2.9
December 23-24/50	10.0	2.1
December 26-27/50	13.0	2.1
January 14-15/51	32.0	3.0
March 26-27/51	103.0	3.0
June 18/51	187.0	1.5
September 5/51	266.0	1.2
January 21/52	404.0	1.4
May 12/52	516.0	0.7
August 26/52	622.0	0.3†
February 1/53	781.0	0.6†
February 23/53	802.0	0.6†

* By bismuth phosphate-lanthanum fluoride co-precipitation method described in report MON-H-218, "Procedure for the Determination of Plutonium in Human Urine", by L. B. Farabee.

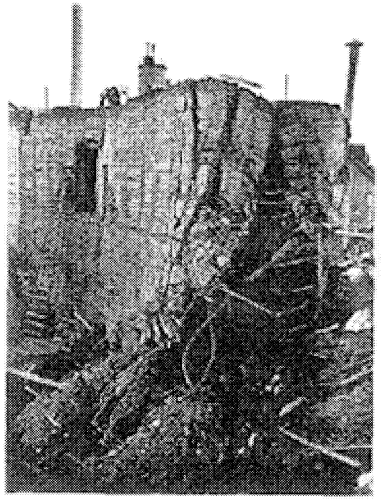
† With the method and technique used these counts are just distinguishable from background.

†† Not distinguishable from background.

2009 September 14

34 Fatal Explosion of Effluent Evaporator in Building 224

Preventative Maintenance



Explosive damage to south east corner of Building 224

It has been mistakenly claimed that no one ever died at the Chalk River Laboratories (CRL) site. This misconception may have arisen because of the change in CRL's status in April 1952 from being a division of the National Research Council of Canada to being a separate crown corporation known as Atomic Energy of Canada Limited (AECL). With this change, a loss in corporate history, combined with the passage of time and changes in staff at CRL, resulted in loss of knowledge of the accident. In addition, the accident took place in the era of Cold War secrecy so it would not have been publicized as it would be today with our industry's emphasis on sharing operations experience.

1950 December 13 A process evaporator was used to reduce the volume of liquid waste at the tail end of the plutonium separation plant. Operators were unable to accurately read the volume and the concentration of the solution they were working with due to errors in the instruments used to measure the solution. At approximately 13:15 the evaporator, which contained about 90 kg of ammonium nitrate, exploded and caused extensive damage to the building. Four workers were injured, a fifth was fatally wounded.

Lessons To Be Learned (LTBL)

A comprehensive Preventive Maintenance (PM) Program on system control instrumentation is only effective when adhered to as prescribed.

Failure to maintain control instrumentation will push your ability to operate systems and processes back into the 1950's.